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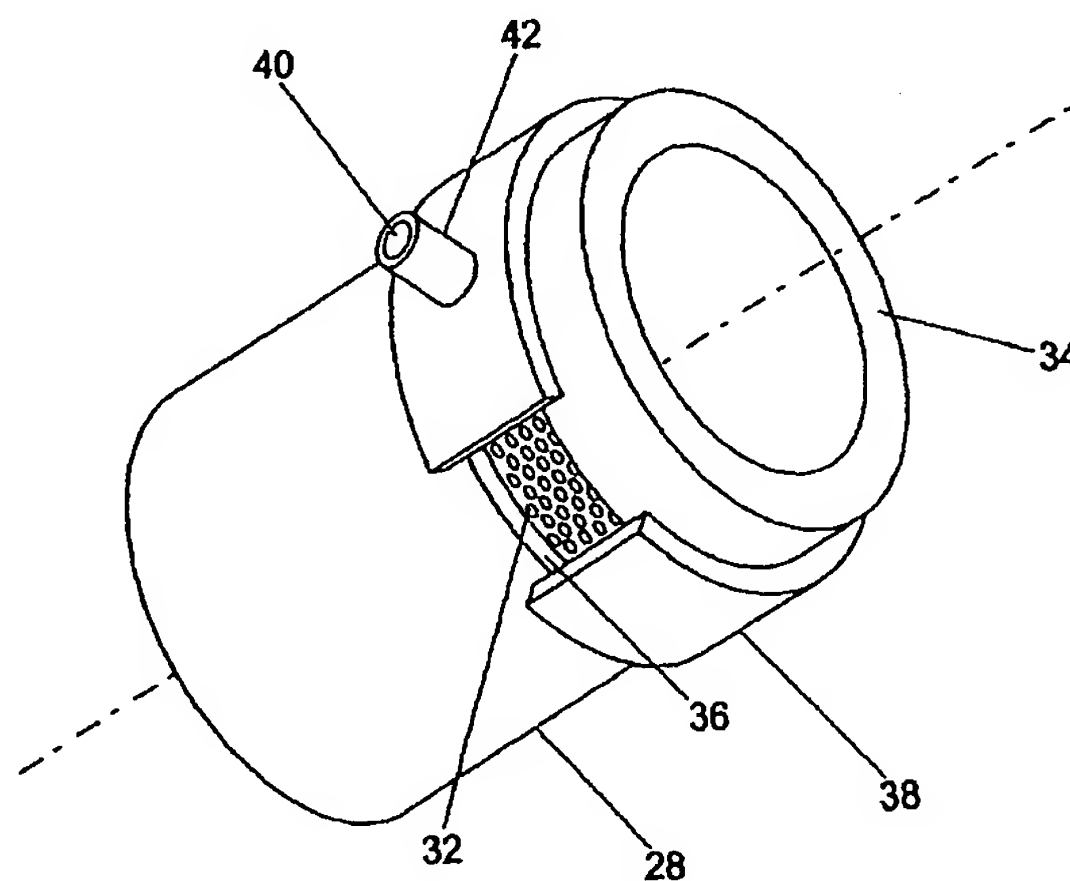
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(54) Title: **LINED PIPE ANNULAR VENTING DEVICE**



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(57) Abstract: A fluid vent (26) for venting fluid from the annulus between the inner surface of a rigid conduit (20) and the outer surface of a conduit liner (10). The fluid vent (26) consists of a length of rigid conduit (34) containing a multiplicity of apertures (32) extending through the wall of the conduit and arranged in an annular pattern around the circumference of conduit (34). The fluid vent (26) further comprises means defining a closed annular volume (36) extending around the exterior circumference of the conduit (34) and interconnecting the outer ends of the apertures (32) with at least one fluid outlet passage (40) located on the exterior of the conduit (34) and communicating with said annular volume (36). The fluid vent can be used to expel water or other liquids from the annular space when retro-fitting a liner to a conduit, venting gas which has permeated through the lining into the annulus, or for assisting in the movement of fluid through the annulus.

LINED PIPE ANNULAR VENTING DEVICE

1.
2
3 The present invention relates to devices and methods
4 for venting fluids from the annulus between a rigid
5 pipeline and a liner inside the pipeline. The
6 invention is particularly applicable to subsea
7 pipelines and may be used for expelling water from
8 the annulus when a liner is retro-fitted to an
9 existing submerged pipeline and/or for venting
10 fluids (especially gases) which permeate from fluid
11 in the pipeline through the liner and into the
12 annulus in use of the pipeline.
13
14 It is well known to line pipelines such as rigid
15 steel pipelines with close fitting plastic lining
16 sleeves ("liners"); e.g. for protecting the interior
17 surface of the pipeline against corrosion by fluids
18 flowing through the pipeline. In certain cases it
19 is necessary to provide some means for venting
20 fluids from the small annular space between the
21 liner and the pipeline to the exterior of the
22 pipeline. This is because fluids conveyed in the

1 pipeline are often polyphasic, that is, they have
2 liquid phase components and gas phase components
3 such as Carbon Dioxide and Hydrogen Sulphide. For
4 example, the plastic materials (typically HDPE) from
5 which the liners are formed are gas permeable so
6 that in use of the lined pipeline, gases may
7 permeate from product flowing in the pipeline,
8 through the liner and into the annulus. The
9 collection of gas in the annulus causes a variety of
10 problems, in extreme cases leading to collapse of
11 the liner if the pressure inside the liner is
12 reduced for any reason.

13

14 A problem associated with venting arrangements
15 providing a fluid path between the annulus and the
16 exterior of the pipeline is that high pressure
17 within the liner may cause the liner material to
18 deform or extrude into an aperture formed in the
19 wall of the pipeline, which can result in puncturing
20 or rupturing of the liner or blocking of vent
21 apertures so as to prevent proper venting of gases.
22 Examples of arrangements for venting gases from
23 lined pipes are disclosed in US-A-4691740, in which
24 apertures are formed in a small area of the pipeline
25 wall and a gas permeable support member is located
26 inside the pipeline wall adjacent the apertures to
27 prevent the liner cold-flowing into the apertures.
28 WO-A-00/08368 discloses further examples, in which
29 an aperture is formed in the pipeline wall and an
30 assembly including a porous plug and a one way valve
31 is installed in the aperture.

32

1. These arrangements provide a very limited flow rate
2 through the vent and are suitable only for venting
3 relatively small volumes of gases which permeate
4 through the liner over an extended period of time.

5
6 Referring to Fig. 3 of the accompanying drawings,
7 one method of installing a liner 12 inside a
8 pipeline 10 is to deform the cylindrical liner 10
9 into a U-shape, which can pass freely through the
10 interior of the pipeline 10, draw the deformed liner
11 12 through the pipeline and then pressurise the
12 interior of the liner so that it reverts to its
13 original cylindrical shape fitting closely against
14 the inside of the pipeline. For subsea lined
15 pipelines, the liner is normally installed in the
16 pipeline prior to the pipeline being laid on the
17 seabed. Examples of U-shaped liner installation
18 methods are disclosed in GB-A-1580438, US-A-4863365,
19 US-A-4986951 and EP-A-0943417.

20
21 It would be desirable to be able to retro-fit a
22 liner to an existing, submerged pipeline. In this
23 case, the pipeline would be flooded with water prior
24 to installing the deformed U-shaped liner. When the
25 liner is subsequently pressurised, the water
26 contained in the pipeline would have to be expelled
27 from the annulus between the liner and the pipeline.
28 Gas-venting systems such as those disclosed in US-A-
29 4691740 and WO-A-00/08368 are unsuitable for venting
30 relatively large volumes of liquid in a reasonable
31 time.

32

1 The present invention concerns arrangements for
2 venting fluids from the annulus of a lined pipeline
3 at a relatively high rate of flow, enabling water to
4 be expelled from the annulus when a liner is fitted
5 to an existing subsea pipeline. The same venting
6 arrangements may also be employed for other purposes
7 such as venting gases which permeate through the
8 liner in use of the pipeline.

9
10 In accordance with the invention, there is provided
11 fluid vent apparatus for venting fluid from an
12 annulus between a rigid conduit and a liner
13 extending along the interior of said conduit, said
14 apparatus comprising a length of rigid conduit
15 including a conduit wall and having a multiplicity
16 of apertures extending through said wall and
17 arranged in an annular pattern extending around the
18 circumference of said conduit, said apparatus
19 further comprising means defining a closed annular
20 volume extending around the exterior circumference
21 of said conduit and interconnecting the outer ends
22 of said apertures, and at least one fluid outlet
23 passage located on the exterior of said conduit and
24 communicating with said annular volume.

25
26 Preferably, said annular volume is closed by a ring
27 member extending around the exterior surface of said
28 conduit and secured thereto on either side of said
29 annular volume.

30
31 Preferably, said annular volume is defined by a
32 groove formed around the exterior surface of said

1 conduit.

2

3 Preferably, the dimensions of said apertures are
4 selected to prevent the material of a liner of
5 predetermined parameters from extruding into said
6 apertures under predetermined pressure and
7 temperature conditions.

8

9 Preferably, the number of said apertures and the
10 dimensions of said fluid outlet passage and said
11 annular volume are selected to allow a predetermined
12 flow rate from the interior of said conduit to the
13 exterior thereof via said fluid outlet passage.

14

15 Most preferably, the fluid vent apparatus comprises
16 a pipe connector device having first and second
17 connector means located at either end of said
18 conduit.

19

20 Embodiments of the invention will now be described,
21 by way of example only, with reference to the
22 accompanying drawings in which:

23

24 Fig. 1 is a side view of a pipeline fitted with
25 fluid venting devices in accordance with one
26 embodiment of the present invention;

27

28 Fig. 2 is an enlarged, sectional side view of part
29 of one of the fluid venting devices of Fig. 1;

30

31 Fig. 3 is a cross sectional view of a pipeline
32 illustrating a known U-shaped liner installation

1 method; and

2

3 Fig. 4 is a perspective view of a fluid venting
4 device as illustrated in Figs. 1 and 2.

5

6 Referring now to the drawings, Fig. 1 shows a length
7 of rigid pipeline 20 having a conventional flange
8 connection 22 at either end. Connected to each of
9 the flange connections 22 is a flanged pipe
10 connector device 24 incorporating a fluid vent 26 in
11 accordance with the present invention. Each of the
12 connector devices 24 comprises a length of conduit
13 28 having a flange connection 30 at each end
14 thereof, the fluid vent 26 being located in the
15 middle of the conduit 28.

16

17 The fluid vent 26 comprises a multiplicity of
18 apertures 32 formed in the conduit wall 34 and
19 arranged in an annular pattern extending around the
20 circumference of the conduit 28. An annular groove
21 36 is formed in the exterior surface of the conduit
22 wall 34, defining an annular volume interconnecting
23 the outer ends of the apertures 32. The annular
24 volume defined by the groove 36 is closed by an
25 outer ring member 38 surrounding the conduit 28 and
26 welded thereto on either side of the groove 36.

27 Fig. 2 shows the ring 38 spaced from the outer
28 surface of the conduit 28 for clarity of
29 illustration. Fig. 4 illustrates the arrangement
30 more clearly, with part of the ring 38 removed to
31 show the apertures 32 and groove 36. A fluid outlet
32 passage 40 is formed through the ring 38 and a

1 spigot 42 connected to the outer surface thereof. A
2 one-way vent valve 44 may be connected to the outer
3 end of the spigot 42, by means of any suitable type
4 of connector 46 formed at the end of the spigot 42.
5 A plug may also be used to relieve pressure in the
6 annulus. The fluid outlet passage 40 communicates
7 with the annular volume defined by the groove 36
8 and, via the apertures 32, with the interior of the
9 conduit 34. Accordingly, fluid contained between
10 the inner surface of the conduit 28 and a liner
11 inside the conduit may be expelled or vented via the
12 apertures 32 and fluid outlet passage 40.

13

14 In this embodiment, the apertures 32 comprise an
15 annular array of small diameter circular holes. The
16 diameter of the holes is selected to be sufficiently
17 small as to prevent the material of the liner being
18 deformed into or extruded through the apertures 32
19 by elevated pressure inside the liner, having regard
20 to the properties of the liner material, the liner
21 thickness, and the expected operating temperatures
22 and pressures. For typical subsea applications
23 involving the use of liners of relatively soft HDPE
24 material having a thickness of about 10 mm and
25 working pressures up to about 450 bar, the apertures
26 32 may suitably have a maximum diameter of the order
27 of 3 mm. This allows a relatively high safety
28 factor of about 4, in view of the fact that HDPE
29 exhibits long term tensile creep at elevated
30 temperatures.

31

32 The cross sectional area of the fluid outlet passage

1 40 is selected to allow flow rates up to a
2 predetermined value sufficient to allow the relevant
3 volume of fluid to be expelled in a reasonable time
4 period. The necessary flow rate may be determined
5 by the inner diameter of the pipe and the length of
6 the pipe between vents (i.e. by the total volume of
7 fluid to be expelled through the vents) and by the
8 desired time period within which the fluid is to be
9 expelled. For the purposes of expelling water
10 during retro-fitting of a liner to a pipeline of the
11 order of 2 - 3 km in length with an inner diameter
12 of 10 - 16 inches (25.4 - 40.6 cm), the fluid outlet
13 passage might suitably have a diameter of the order
14 of 25 - 40 mm. The corresponding total cross-
15 sectional area which needs to be provided by the
16 multiple small apertures 32 for a given flow rate
17 may be determined in a similar manner, and hence the
18 required number of apertures 32 of a given size may
19 be calculated. Generally speaking, the total area
20 of the small apertures 32 should be at least about
21 equal to the area of the fluid passage 40. For
22 example, if the fluid passage has a diameter of 40
23 mm and the apertures have a diameter of 3 mm,
24 approximately 180 small apertures would be required.
25 The cross sectional area of the annular volume
26 defined by the groove 36 may also be determined on
27 the basis of the required flow rate, corresponding
28 generally to the cross sectional area of the fluid
29 outlet passage 40.
30
31 More than one fluid outlet passage 40 may be
32 provided around the circumference of the ring 38, in

1 which case the diameter of the individual outlet
2 passages may be reduced for a given total flow rate,
3 as may the cross sectional area of the annular
4 volume defined by the groove 36.

5

6 The apertures 32 may be formed by any suitable means
7 including drilling, laser cutting and electrical
8 spark erosion. The apertures 32 need not be
9 circular. For example, they could be formed as
10 slots or the like, provided that the dimensions of
11 the apertures are sufficiently small to prevent
12 deformation/extrusion of the liner material.

13

14 It will be understood that forming the apertures 32
15 and groove 36 in the wall of the conduit 28
16 necessarily reduces the strength of the conduit,
17 lowering its resistance to collapse and bursting.
18 However, this is compensated for by the ring member
19 38, which effectively reinforces the weakened
20 portion of the conduit 28.

21

22 The construction of the vent assembly may also vary
23 from that of the present embodiment, in which the
24 apertures 32 and the annular volume interconnecting
25 the apertures 32 are formed in the wall of the
26 conduit 28. The apertures 32 may be formed in a
27 separate annular member located inside the conduit
28 or connected between two lengths of conduit. The
29 annular volume may be formed in the outer ring
30 rather than in the conduit or other member
31 containing the apertures 32, or in a combination
32 thereof. Alternatively, the main body of the device

1 24 could be formed from two standard tapered flange
2 connectors welded back to back with the outer ring
3 extending around the union between the two
4 connectors so that a shallow V-section annular
5 volume is defined between the ring and the outer
6 tapered surfaces of the joined connectors. Other
7 possible arrangements may be envisaged, provided
8 that the assembly provides a multiplicity of small
9 apertures, an outer volume interconnecting the
10 apertures and at least one fluid outlet
11 communicating with the outer volume.

12

13 It will be appreciated that a vent arrangement of
14 this type may be incorporated into any length of
15 pipeline. However, it is preferred that the
16 arrangement is incorporated into a connector device
17 which may be connected to the end of a length of
18 pipeline or between adjacent lengths of pipeline,
19 particularly for the purpose of retro-fitting a
20 liner to an existing subsea pipeline. It will
21 further be appreciated that such a device may employ
22 end connectors of types other than flange
23 connections.

24

25 In use of the invention for the purpose of
26 installing a liner in a subsea pipeline, one of the
27 devices 24 is fitted to each end of the length of
28 pipeline which is to be lined. The U-shaped liner
29 is pulled through the pipeline from one end thereof,
30 trimmed to length and its ends secured and sealed to
31 the outer ends of the devices 24 by any suitable
32 means (as known in the art). During this process, a

1 large volume of water is trapped between the liner
2 and the inner diameter of the pipeline. The
3 interior of the liner is then pressurised so as to
4 expand and revert to its circular shape to fit the
5 inner diameter of the pipeline, the water trapped in
6 the annulus being expelled through the vents 26.
7 The arrangement of the vents allows a relatively
8 high flow rate therethrough, so that the process may
9 be carried out economically. Pockets of water may
10 remain trapped between the liner and the pipe after
11 the liner has been pressurised. If necessary, such
12 pockets may be expelled by running a pig along the
13 interior of the liner so as to push any trapped
14 water to one end of the pipe, where it may be
15 expelled through the vent 24 located downstream of
16 the pig. Vent valves 44 may subsequently be fitted
17 to the vents 24 for in-service venting of permeating
18 gases.

19
20 For the purpose of venting permeated gases, the
21 provision of the annular array of apertures 32 and
22 the annular volume defined by the groove 36 means
23 that the fluid outlet passage 40 does not have to be
24 accurately aligned at any particular point on the
25 circumference of the pipe. Gases collected at the
26 fluid outlet passage 40 can be vented to the surface
27 or to a subsea atmospheric pressure canister (not
28 shown) which can be attached to the fluid outlet
29 passage 40.

30
31 In order to facilitate the passage of permeated
32 gases to the vent port, it may be desirable for the

1 outer surface of the liner to be provided with
2 grooves which act as channels communicating with the
3 vent port. Such liner grooves improve the
4 circulation and thermal transfer of fluids within
5 the annulus and can be used to control and measure
6 the flow of fluids around the annulus. The annular
7 array of apertures makes it easier for a number of
8 such grooves to communicate with the vent port.
9 In addition, the annular groove 36 can be modified
10 by the addition of bulkheads to partition the
11 annular groove. The partitions allow the liner
12 grooves to be linked together thereby creating fluid
13 flow across the annular groove 36.

14

15 The invention thus provides an improved fluid vent
16 for a lined pipe which makes possible the retro-
17 fitting of liners to subsea pipelines by allowing
18 excess pressure trapped in the annulus to be vented
19 harmlessly, removing any long term risk of liner
20 collapse due to either flow induced collapse or
21 trapped gas build up from transported fluids.

22

23 Improvements and modifications may be incorporated
24 without departing from the scope of the invention.

25

26

27

1 Claims

2

3 1. Fluid vent apparatus for venting fluid from an
4 annulus between a rigid conduit and a liner
5 extending along the interior of said conduit, said
6 apparatus comprising a length of rigid conduit
7 including a conduit wall and having a multiplicity
8 of apertures extending through said wall and
9 arranged in an annular pattern extending around the
10 circumference of said conduit, said apparatus
11 further comprising means defining a closed annular
12 volume extending around the exterior circumference
13 of said conduit and interconnecting the outer ends
14 of said apertures, and at least one fluid outlet
15 passage located on the exterior of said conduit and
16 communicating with said annular volume.

17

18 2. Fluid vent apparatus as claimed in Claim 1,
19 wherein said annular volume is closed by a ring
20 member extending around the exterior surface of said
21 conduit and secured thereto on either side of said
22 annular volume.

23

24 3. Fluid vent apparatus as claimed in Claim 1 or
25 Claim 2, wherein said annular volume is defined by a
26 groove formed around the exterior surface of said
27 conduit.

28

29 4. Fluid vent apparatus as claimed in any
30 preceding Claim, wherein the dimensions of said
31 apertures are selected to prevent the material of a
32 liner of predetermined parameters from extruding

1 into said apertures under predetermined temperature
2 and pressure conditions.

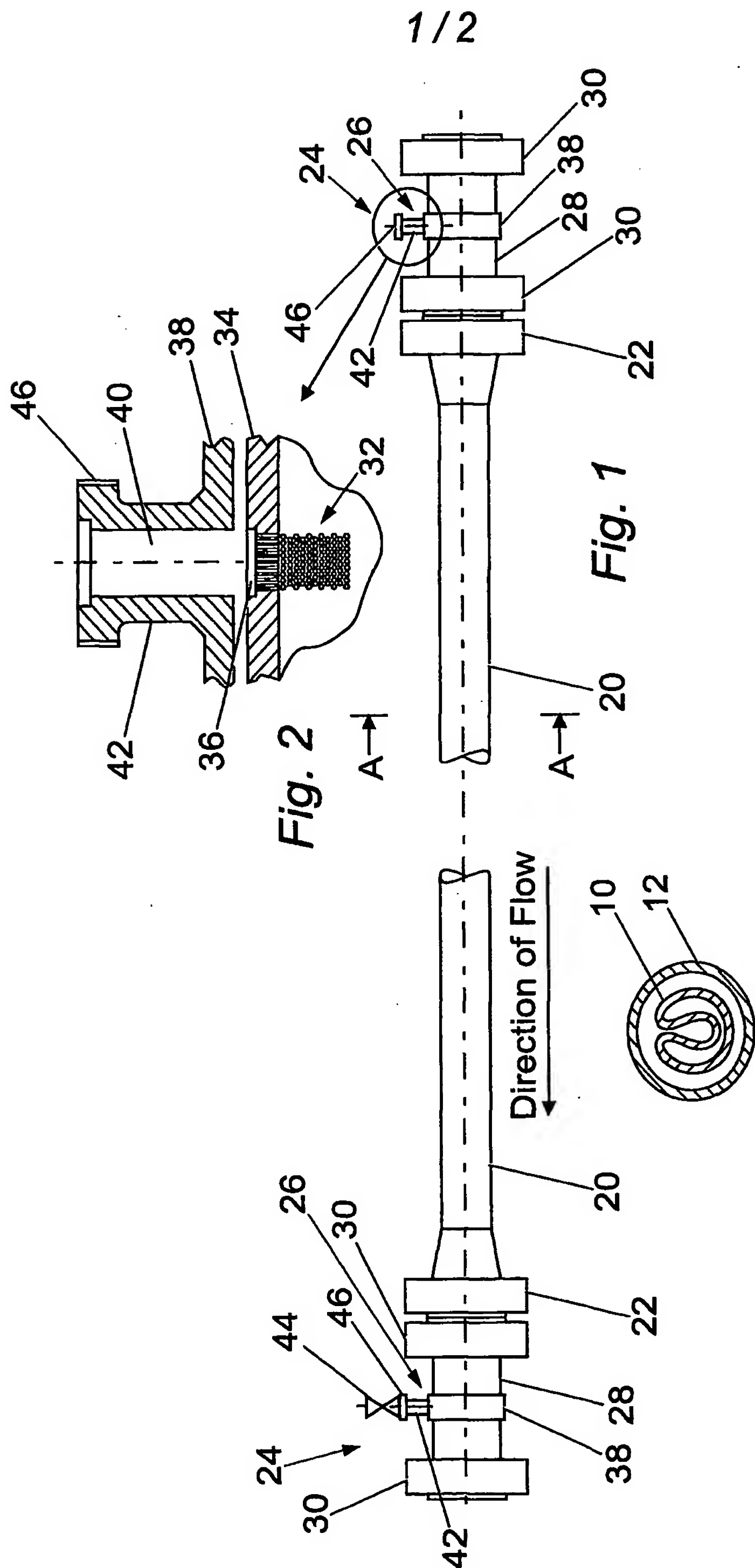
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4 5. Fluid vent apparatus as claimed in any
5 preceding Claim, wherein the number and dimensions
6 of said apertures and the dimensions of said fluid
7 outlet passage and said annular volume are selected
8 to allow a predetermined flow rate from the interior
9 of said conduit to the exterior thereof via said
10 fluid outlet passage.

11

12 6. Fluid vent apparatus as claimed in any
13 preceding Claim, comprising a pipe connector device
14 having first and second connector means located at
15 either end of said conduit.

16



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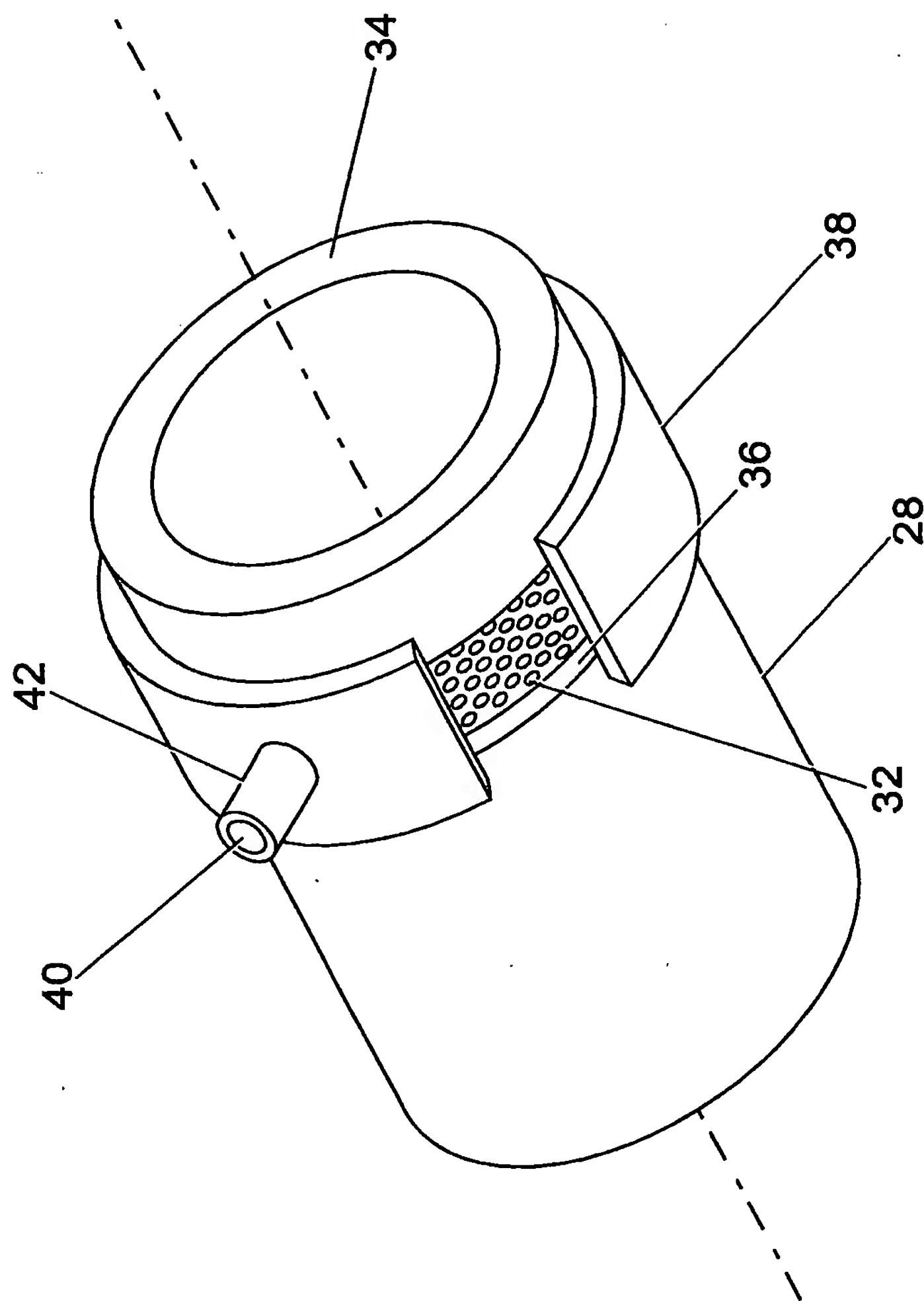


Fig. 4

INTERNATIONAL SEARCH REPORT

Inter Application No
PCT/GB 01/02435

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
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 information on patent family members

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